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Shape change of metal oxide nanoparticles produced by laser ablation in liquid

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The shape variation of the nanoparticles (NPs) is important for several applications including creation of the antibacterial coatings and nanotoxicological research. Currently, the expansion of the study of nanoparticle toxicity needs production of the stable colloids (water suspensions) of high metal oxide concentration with model pure NPs of given composition, sizes and shapes [1,2]. The laser ablation in water (LAW) gives the unique ability to produce the colloids of spherical NPs. Moreover, the NPs can be transformed from octahedron to spherical shape by non-focused laser irradiation in a liquid in short time. However, other morphologies such as hollow particles, cubes, rods, spindles, tubes, disks, plates and sheets also have been fabricated with the assistance of external factors and directly by LAW.

The formation of metal oxide NPs and nanostructuring of the target surface by LAW and hot water treatment have been studied using Pb as a model metal. The pulse Yb fiber laser (Fmark-20 RL, Laser technology center Ltd) with 1062 nm wavelength, 100 ns pulse duration and repetition rate about 21 kHz has been used for laser ablation. The 2-mm-thick Pb target of 99.99% purity with diameter 46 mm at the bottom of the glass Petri dish was covered by 5 mm layer of deionized water. The water volume was about 40 ml. The focused laser beam (fluence 80 J/cm^2, spot diameter 40 μm) has been scanned over the target area about 16 mm^2 with linear velocity 270 mm/s. The typical duration of the ablation process was about 240 s. The water temperature near the target surface was measured by thermocouple. Various target surface preparations have been used: (1) aging by long exposure at ambient conditions, (2) cleaning by LAW and subsequent ultrasonification, (3) etching by CCP oxygen plasma, (4) treating by hot deionized water [3].

It was found that the laser ablation of the targets aged at ambient conditions, cleaned by LAW and treated by hot water leads to appearance of nonspherical 2D (plates) and 3D (octahedra and rods) NPs in suspension and at the target surface. The NPs of the classical spherical shape appeared in suspension immediately after LAW and their shape changes rapidly in the heated water. It was found that the octahedra and rods appeared at the target surfaces immersed in the water with temperature about 70 ºC after several minutes even without laser ablation. Thus, the noticeable role of the unavoidable hot water treatment during LAW in formation of the nonspherical micro- and nanoparticles was proved.

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